



## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification: <b>G06F 15/173</b>	A1	(11) International Publication Number: <b>WO 00/41091</b> (43) International Publication Date: <b>13 July 2000 (13.07.2000)</b>
(21) International Application Number: <b>PCT/US99/28199</b>		
(22) International Filing Date: 29 November 1999 (29.11.1999)		<b>Published</b>
(30) Priority Data: 09/223,829 31 December 1998 (31.12.1998) US		
(60) Parent Application or Grant 3COM CORPORATION [/]; O. EICHERT, Stuart [/]; O. NESSETT, Danny, M. [/]; O. LUO, Wenjun [/]; O. LUSHER, Elaine [/]; O. RICHARDSON, Kent, R. ; O.		

(54) **Title: DYNAMIC POLICY MANAGEMENT APPARATUS AND METHOD USING ACTIVE NETWORK DEVICES**  
 (54) **Titre: GESTION DYNAMIQUE D'UNE POLITIQUE, ET APPAREIL ET PROCEDES UTILISANT DES DISPOSITIFS ACTIFS DE RESEAU**

**(57) Abstract**

A system for providing policy management in a network (110) that includes nodes (100, 120, 130, 140, 150, 160, 170, 180, 190) operating in multiple protocol layers and having enforcement functions. Multiple network devices, such as routers (160), hubs (190), remote access equipment (150), switches (120), repeaters (140), bridges (170), and network cards (130, 180), and end system processes having security functions are configured to contribute to implementation of policy enforcement in the network (110). By distributing policy enforcement functionality to a variety of network devices and end systems, a pervasive policy management system is implemented. The policy management system includes a policy implementation component that accepts policy, i.e. instructions or rules, that define how the network device should behave when confronted with a particular situation. The management system further includes a management station (100), with a user interface (101) operating pursuant to a first process capable of providing an object to the network, the object including variables and one of a method or instructions to locate a method, executable on the network to set up a second process to enforce a portion of the policy.

**(57) Abrégé**

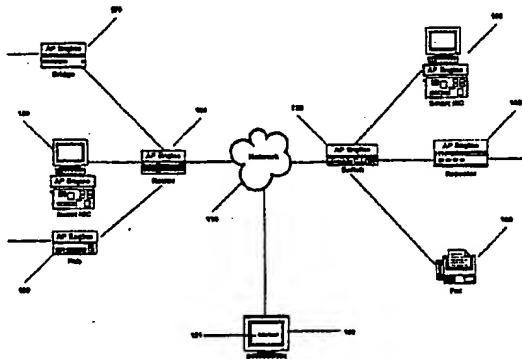
L'invention porte sur un système de gestion de la politique d'un réseau (110) comportant des noeuds (100, 120, 130, 140, 150, 160, 170, 180, 190) fonctionnant dans plusieurs couches de protocoles à fonctions exécutoires. De multiples éléments du réseau tels que des routeurs (160), des concentrateurs (190), des équipements d'accès à distance (150), des commutateurs (120), des répéteurs (140), des passerelles (170), des cartes réseaux (130, 180), et des processus de système finaux à fonctions sécuritaires sont conçus pour contribuer à mettre en oeuvre l'exécution de la politique dans le réseau (110). La répartition des fonctions exécutoires de la politique entre divers dispositifs et systèmes finaux du réseau donne un système de gestion de la politique puissant qui comporte un élément de gestion d'acceptation de la politique c.-à-d. des instructions ou règles définissant comment un dispositif du réseau doit se comporter face à une situation particulière. Le système de gestion comprend en outre une station (100) de gestion munie d'une interface (101) utilisant agissant selon un premier processus capable de fournir au réseau un objet comportant des variables et l'une des méthodes ou instructions localisant une méthode exécutable sur le réseau pour établir un deuxième processus faisant exécuter une partie de la politique.

PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION  
International Bureau



INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : <b>G06F 15/173</b>		A1	(11) International Publication Number: <b>WO 00/41091</b> (43) International Publication Date: <b>13 July 2000 (13.07.00)</b>
<p>(21) International Application Number: <b>PCT/US99/28199</b></p> <p>(22) International Filing Date: <b>29 November 1999 (29.11.99)</b></p> <p>(30) Priority Data: 09/223,829 31 December 1998 (31.12.98) US</p> <p>(71) Applicant: <b>3COM CORPORATION [US/US]; 5400 Bayfront Plaza, Santa Clara, CA 95052-8145 (US).</b></p> <p>(72) Inventors: <b>EICHERT, Stuart; 119 Tower Road, Middlebury, CT 06762-3138 (US). NESSETT, Danny, M.; 34810 Wabash River Place, Fremont, CA 94555 (US). LUO, Wenjun; 40664 Witherspoon Terrace, Fremont, CA 94538 (US). LUSHER, Elaine; 456 Montori Court, Pleasanton, CA 94566 (US).</b></p> <p>(74) Agent: <b>RICHARDSON, Kent, R.; Wilson Sonsini Goodrich &amp; Rosati, 650 Page Mill Road, Palo Alto, CA 94304-1050 (US).</b></p>		<p>(81) Designated States: CA, GB, JP, European patent (AT, BE, CH, CY, DE, DK, ES, FL, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).</p> <p>Published <i>With international search report.</i></p>	
<p>(54) Title: <b>DYNAMIC POLICY MANAGEMENT APPARATUS AND METHOD USING ACTIVE NETWORK DEVICES</b></p> 			
<p>(57) Abstract</p> <p>A system for providing policy management in a network (110) that includes nodes (100, 120, 130, 140, 150, 160, 170, 180, 190) operating in multiple protocol layers and having enforcement functions. Multiple network devices, such as routers (160), hubs (190), remote access equipment (150), switches (120), repeaters (140), bridges (170), and network cards (130, 180), and end system processes having security functions are configured to contribute to implementation of policy enforcement in the network (110). By distributing policy enforcement functionality to a variety of network devices and end systems, a pervasive policy management system is implemented. The policy management system includes a policy implementation component that accepts policy, i.e. instructions or rules, that define how the network device should behave when confronted with a particular situation. The management system further includes a management station (100), with a user interface (101) operating pursuant to a first process capable of providing an object to the network, the object including variables and one of a method or instructions to locate a method, executable on the network to set up a second process to enforce a portion of the policy.</p>			

**FOR THE PURPOSES OF INFORMATION ONLY**

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GR	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece	ML	Mali	TR	Turkey
BC	Bulgaria	HU	Hungary	MN	Mongolia	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MR	Mauritania	UA	Ukraine
BR	Brazil	IL	Israel	MW	Malawi	UG	Uganda
BY	Belarus	IS	Iceland	MX	Mexico	US	United States of America
CA	Canada	IT	Italy	NE	Niger	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NL	Netherlands	VN	Viet Nam
CG	Congo	KE	Kenya	NO	Norway	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NZ	New Zealand	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	PL	Poland		
CM	Cameroon	KR	Republic of Korea	PT	Portugal		
CN	China	KZ	Kazakhstan	RO	Romania		
CU	Cuba	LC	Saint Lucia	RU	Russian Federation		
CZ	Czech Republic	LI	Liechtenstein	SD	Sudan		
DE	Germany	LK	Sri Lanka	SE	Sweden		
DK	Denmark	LR	Liberia	SG	Singapore		
EE	Estonia						

**Description**

**5**

**10**

**15**

**20**

**25**

**30**

**35**

**40**

**45**

**50**

**55**

5

10

5

## DYNAMIC POLICY MANAGEMENT APPARATUS AND METHOD USING ACTIVE NETWORK DEVICES

### BACKGROUND OF THE INVENTION

15

#### Field of the Invention

The present invention relates to establishing and enforcing system policy on a network; 10 and more specifically to systems employing dynamic policy management using active networking devices to establish and enforce system policy.

20

#### Discussion of the Related Art

The Internet has grown significantly over the past several decades, yet there are signs 25 that applications would benefit from a richer set of Internet services. For example, the expected growth in voice over IP (VoIP) traffic on the Internet will change its overall traffic characteristics. While up to now real-time delivery requirements for IP traffic have been rare, 30 VoIP packets must be delivered within fairly strict time constraints. Since the volume of VoIP traffic is likely to grow into a high percentage of Internet traffic, the services required 20 by the Internet will change. As other real-time traffic, such as that supporting video, becomes prominent, the effect on Internet services will be even more dramatic.

35

The growth of the Internet and the use of IP based technology has also created a corresponding growth in the number of systems administrators must manage. This scaling problem is being addressed by the use of policy based management systems, whereby 40 administrators specify what should happen and leave it to the policy management system to determine procedures to implement the policy.

45

The system administrators' task of administering policy is even further complicated by legacy systems. As networks evolve, older equipment, i.e., legacy systems, remain that may 50 not be able to participate in a particular management policy. Alternately, legacy systems may 30 be able to participate, but the methods required to execute the policy are different, thereby complicating the implementation of the policy. Because of the variety of devices and legacy systems, the complexity of implementing a management policy makes it difficult to establish

55

55

5 the policy across all layers and device types of the network, and particularly difficult to maintain such a policy management system even if it could be successfully implemented.

10 Typically in the prior art a central management station that dispatches instructions to the network devices as needed controls the policy management. The instructions may be 15 very basic, such as telling the device to shut down, or very complex requiring the device. Often the instructions are in response to repetitive processes that are executed periodically, i.e., daily or weekly, or on the occurrence of some event. If system congestion is high or the management system is inoperative, the appropriate action may not be taken, thereby creating system performance degradation; and in the worse case scenario this could lead to system 20 failure.

Accordingly, it is desirable to implement a policy management system which allows 25 for system policy to be executed and maintained at the network device level across layers of network systems and protocols.

25 15 SUMMARY OF THE INVENTION

Accordingly, the present invention is directed to a dynamic policy management apparatus and method using active network devices that provide for policy enforcement.

30 The present invention provides a system for providing policy management in a 35 network that includes passive nodes and active nodes operating in multiple protocol layers and having enforcement functions. A variety of network devices, i.e., nodes or active nodes, such as routers, remote access equipment, switches, repeaters, network cards, and end system processes having security functions, are configured to contribute to the implementation of 40 policy enforcement in the network. By distributing policy enforcement functionality to a 45 variety of network devices and end systems, a pervasive policy management system is implemented. The policy management system includes a policy implementation component that accepts policy, i.e., instructions or rules that define how the network device should 50 behave when confronted with a particular situation. The policy enforcement is performed by network devices having tools and resources to execute the active packets distributed throughout the network to enforce the defined policy. The policy being implemented can be implemented across multiple protocol layers and must be coordinated by the policy management system such that particular devices enforce that part of the policy pertinent to their part of the network.

5 For example, a router in the network enforces that part of the policy that is pertinent to those systems and network devices whose traffic might traverse the router. A switch  
10 enforces that part of the policy that is pertinent to those systems and network devices whose traffic traverses the switch. A repeater enforces that part of the policy that is pertinent to  
15 those systems and network devices whose traffic traverses the repeater. A network interface card with processing resources (smart NIC) enforces that part of the policy that is pertinent to the system or device to which it is connected. In addition, other parts of the network are  
20 included in the policy management hierarchy, such as end system operating systems and applications, remote access equipment, network management systems for controlling network traffic and monitoring network traffic, and other auxiliary systems such as name services and file services are included in the collection of network devices that are called upon to enforce a  
25 portion of the policy being implemented by the present invention.

To implement the system policy a network manager uses a management station to specify policy for a network. The management station employs a policy definition system  
25 (PDS) supporting a policy definition language (PDL) to create a programming language active packet, which represents at least one rule of the policy, which is then encapsulated in preparation for transmission to the active network devices. The active packet includes, but is  
30 not limited to, an object-oriented programming language, such as C++, CAML, JAVA, and Python, having objects and scripting programming language, such as Practical Extraction and  
35 Report Language (PERL), Tool Command Language (TCL), or employing shells, e.g. Unix supports Bourne shell, Korn shell, and C-shell code. The active packet is stored in an active packet file on a memory device and the file is optionally signed with a digital signature. The active packet file is either deposited in a network directory, or other distributed database, or  
40 sent through the network to the enforcement device and stored in its memory. The enforcement device is signaled when a new policy, represented by the active packet file, for it is available. The signal may contain the active packet or it may inform the device to find the active packet in a network directory or distributed database.

45 After the enforcement device obtains the active packet file, it is optionally verified via the signature to determine the privileges the active packet should be granted. The active  
50 30 packet file is then extracted from the memory location and the active packet is prepared for execution. The enforcement device checks to see if it has the implementing code (at least one variable, method, and/or data) for the active packet loaded in its memory. If not, the

50

5 enforcement device obtains the code from a distributed database or directory, or another enforcement device, or similar memory device.

10 The policy definition language comprises a mobile programming language which in turn includes, but is not limited to, object-oriented and scripting programming languages. If 15 the mobile programming language is an object-oriented language then the active packet comprises an active object, i.e. code plus data, normally referred to just as an object. For each object a thread of execution is established, and the object is executed. The object then uses the services available to it on the enforcement device to enforce the policy or a portion of the policy. If the mobile programming language is a scripting programming language then 20 the active packets comprises active code, normally referred to just as code. The code along with an interpreter for interpreting the code is transferred to the enforcement device. The code then uses the services available to it on the enforcement device to enforce the policy or a portion of the policy. Several enforcement devices may be utilized to execute a certain policy. Therefore, a particular enforcement device may only enforce a portion of the policy.

25 The reader should note that the remainder of the disclosure will primarily focus on active packets comprising objects. Those of ordinary skill in the art will appreciate that substantially the same processes and procedures applicable to active objects are applicable to active code. Throughout the disclosure any reference made to an object, unless otherwise stated, refers to an object-oriented object and any reference made to code, unless otherwise 30 stated, refers to a code associated with a scripting programming language.

35 The management station software provides the system administrator with resources to input a list of rules describing the policy to be enforced on a network. The management station PDS is a software product that creates one or more programming language active packets as previously explained, which represent the rules. The objects, once created, are in a 40 ready-to-run state and are invoked by a thread of execution to implement the processes that they represent. The invocation of the object establishes a thread that can execute independently of other processes running on the various network devices. A process can have several threads running concurrently, each performing different jobs such as waiting for 45 events to occur or performing some other time consuming task. When a thread has finished 30 its job, the thread is suspended or destroyed and the resources utilized are returned to the system.

50 After the creation of one or more objects, the management station software will encode the objects into a transportable format. Upon the completion of the encoding, the data

5 identifying the code that the objects need in order to be executed is associated with the  
10 encoded transportable objects. After storing the objects to an object file, the management  
station software will optionally sign the file. The purpose of signing the file is to allow the  
15 enforcement device to decide which rights and privileges to grant the objects when they are  
20 executed on the enforcement device.

25 The optionally signed file can either be deposited in a on a storage device, which  
30 includes but is not limited to a directory server or distributed database, or sent to the  
35 enforcement device via the network. If the file has been deposited in a directory server or  
40 distributed database, the management station will either provide the enforcement device with  
45 the address to the storage location or the device will know to retrieve the file at a specified  
50 location. The notification that an object file is available for the enforcement device can occur  
55 in many ways including, but not limited to, the changing of a state or variable that the  
60 enforcement device monitors.

65 If the enforcement device receives a signal indicating that a new policy, represented  
70 by the object file, is available for it on a directory server or distributed database, it will  
75 retrieve the object file. Upon retrieval or receipt of the object file, the enforcement device  
80 will extract the object file contents.

85 The enforcement device will optionally verify the signature of the object file, as  
90 previously stated, to determine which of its base services that it will allocate to the objects in  
95 the signed file to utilize in the implementation of its proscribed functions. The enforcement  
100 device will then examine the data within the file which specifies the code required by the  
105 objects. If it does not have the code stored in its memory, it will extract the code or a  
110 reference to the code from the file. If the code is in the enforcement device's memory it is  
115 then loaded into its program memory and executed. Otherwise, the device uses the reference  
120 to retrieve the code from a directory server or distributed database.

125 The present invention provides distinct advantages over the prior art, in that  
130 traditionally, policy is represented as flat data, requiring an enforcement device to understand  
135 its syntax. If this syntax changes, either to add new kinds of policy terms or to restructure the  
140 representation, all enforcement devices must be reprogrammed to parse the new syntax.

145 With the present invention, the contract between the network device and network  
150 management system involves only the methods that a policy object exports. Thus, new  
155 methods can be added to an object class that control new aspects of policy without affecting  
160

5 legacy enforcement devices. Also, the internal representation of policy may change without affecting either the network management station or the enforcement device.

10 The present invention further supports a process called co-location, which enables the objects to be distributed with their code, or references to their code that implements the 15 policy, throughout the network. Co-location enables new policy implementations to be distributed to devices without changing the underlying base implementations of the devices. For instance, legacy systems would have to be re-booted in order for new policy 20 implementations to be enabled. Co-location permits the legacy systems to continue their base functions undisturbed while a new policy is implementation is distributed to the enforcement 25 devices.

Another advantage of the present invention is the separation of policy rule 20 enforcement, which is accomplished by creating an independent thread for each object 25 representing a particular rule. Network administrators can independently stop or start the enforcement of each rule in the policy specification without affecting the enforcement of 30 other polices in the specification.

Additional features and advantages of the invention will be set forth in the detailed 35 description which follows, and in part will be apparent from the description, or may be learned by practice of the invention. The aspects and other advantages of the invention will 40 be realized and attained by the structure particularly pointed out in the written description and 45 claims hereof as well as the appended drawings.

To achieve these and other advantages and in accordance with the purpose of the 35 present invention, as embodied and broadly described, the present invention can be 40 characterized according to one aspect as a system providing dynamic policy management in a 45 network, including a management station coupled to said network, the management station 50 including resources to store data defining policy rules for a device in the network. Resources in the management station are included for producing an active packet including at least a variable and a method, in response to the data defining the policy rule, the active packet having a format. Resources in the management station are included for sending the active packet to the network device adapted to read and execute the active packet according to the 55 format.

Another aspect of the present invention can be characterized as a system for dynamic 50 policy management in a network, including a network device coupled to said network, the network device including resources to receive an active packet representing a policy rule.

5 from a second device in the network, the active packet having a format; resources in the network device for decoding the active packet according to the format, the active packet including a variable and a method; and resources in the network device for executing the active packet.

10 5 A further aspect of the present invention can be characterized as a system for dynamic policy management in a network including a management station and a network device coupled to said network, wherein the management station includes:

15 1) resources to store data defining a policy rule for a device coupled to the network;  
2) resources in the management station for producing an active packet including a  
10 variable and a method in response to the data defining the policy rule, the active packet  
having a format; and  
20 3) resources in the management station for sending the active packet to the network  
device, wherein the network device includes resources to receive, decode, and execute the  
active packet according to the format.

25 15 A still further aspect of the present invention can be characterized as a system  
providing dynamic policy management by a method, the system, including an interface  
adapted to receive instructions characterizing policy regarding control of a network; and an  
30 active node connected to the interface which provides a packet to the network, the packet  
including one of a variable and a method and a reference to the variable and the method,  
20 executable on the network to set up a process to enforce at least a portion of the policy.

35 Another aspect of the present invention can be characterized as a system for dynamic  
policy management in a network, including a network node adapted to receive a packet,  
created by a first process, representing policy for control of a network; and resources in the  
network node capable of executing a packet including one of a variable and a method and  
40 25 instructions to locate the variable and the method, executable on the network node to enforce  
a portion of the policy.

45 An additional aspect of the present invention can be characterized as a system for  
dynamic policy management in a network, including an active node and a network node  
coupled to said network, wherein the active node includes:

50 30 A) resources to store data defining a policy rule for a device coupled to the network;  
B) resources in the active node for producing a packet including a variable and a  
method in response to the data defining the policy rule; and  
C) resources in the active node for sending a packet file containing one of the packet

5 and a reference to the packet to the network node, wherein the network node includes  
resources to receive, decode, and execute the packet.

10 It is to be understood that both the foregoing general description and the following  
detailed description are exemplary and explanatory and are intended to provide further  
15 5 explanation of the invention as claimed.

#### BRIEF DESCRIPTION OF THE DRAWINGS

15 The accompanying drawings, which are included to provide a further understanding  
10 of the invention and are incorporated in and constitute a part of this specification, illustrate  
embodiments of the invention and together with the description serve to explain the  
20 principles of the invention. In the drawings:

25 Fig. 1 is schematic diagram illustrating the interconnections of the management  
station, the network and the enforcement devices of the present invention;

30 Fig. 2 depicts a general-purpose computer and its resources of the present invention;

35 Fig. 3 is a flow diagram illustrating the process steps performed by the software  
product for creating and storing the objects of the present invention;

40 Fig. 4 illustrates a stored file of objects and their references to the methods and data  
necessary to execute the object of the present invention;

45 Fig. 5 illustrates a hierarchy of systems executing multiple software products of the  
present invention; and

50 Fig. 6 is a flow diagram illustrating the process steps of the software product for  
deserializing and executing objects of the present invention.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

55 Reference will now be made in detail to the preferred embodiments of the present  
invention, examples of which are illustrated in the accompanying drawings.

45 Fig. 1 illustrates a schematic diagram of a general network and its connected network  
30 devices. The management station 100 comprising an interface 101 is connected to network  
110. Network 110 can be a WAN, LAN, INTERNET, or similar type network wherein  
50 devices are inter-connected and control, i.e., policy, is desired. The intermediate network  
devices, such as switch 120, smart NIC, 130 and 180, repeater 140, router 160, bridge 170

5 and hub 190 are connected to network 110. Peripheral devices such as fax 150, include but  
are not limited to, printers and modems are connected to any one of the intermediate devices.  
10 The intermediate network devices are coupled to an active packet (AP) execution engine, as  
depicted in Fig. 1, which provides resources for executing an active packet created by the  
15 management station 100 pursuant to the policy definition language (PDL) and transferred to a  
network intermediate or end device.

15 Fig. 2 illustrates the resources of management station 100 and Fig. 3 depicts a flow  
diagram of the process steps executed by the PDS software product utilized by the  
management station 100 of the present invention.

20 10 The system administrator inputs instructions representing policy through a interface  
101, which includes but is not limited to a graphical user interface GUI, of management  
station 100. As shown in Fig. 2, the management station 100 comprises a general purpose  
computer operating pursuant to a first software product providing a user interface for  
25 inputting instructions representing system policy. The general-purpose computer includes,  
15 but is not limited to, an IBM, IBM-clone, UNIX workstation, Macintosh, Sun Microsystems,  
or similar computer capable of executing an policy definition system. The management  
station 100 operates pursuant to an operating system including, but not limited to, Windows  
or Windows NT, UNIX, OS/2, Mac OS 8.0 or similar operating system.

30 30 The management station 100 includes a processor 210, memory 220 running a  
20 general-purpose operating system, and an engine operating pursuant to PDS software 230  
such as JAVA Virtual Machine operating pursuant to JAVA. The management station 100  
35 further includes a graphical GUI engine 240 and a smart NIC 250 which provides access to  
the network 110. The system administrator proceeds to input the instructions representing  
40 policy in the form of rules. The rules can be generated at the time of the input and saved for  
future reference or they may have been previously generated to handle specific policy  
45 situations and stored in the memory 220 or some other memory device connected to network  
110 for later access. In one embodiment basic rules are pre-determined and selected from a  
table and populated with at least one variable and a method using the GUI 240 and stored in  
memory 220.

50 30 For example, the system administrator may decide that the system traffic is very  
heavy on Mondays and Fridays causing system congestion, resulting in a degradation of  
system performance. The administrator can implement a policy whereby Internet access may  
be limited or totally eliminated during working hours on Mondays and Fridays. The policy

5 will be created and dispatched to the appropriate network devices to effectuate this policy. In  
Fig. 1 this may be the smart NIC/AP engine combination 130, Router/AP engine combination  
160, or Switch/AP engine combination 120 working alone or in combination to effectuate the  
policy for disabling Internet access on the dates and times in question. The reader should  
10 5 note that from this point on in the disclosure that a reference to switch 120, smart NIC 130,  
repeater 140, router 160, bridge 170, and hub 190, of Fig. 1, also includes the AP engine that  
the aforementioned devices are in communication with.

15 The rules contain a variety of information necessary to effectuate the current policy or  
policies dictated by the system administrator. For instance, the rules may contain information  
10 10 which includes, but is not limited to, network and transport layer source addresses, network  
and transport layer destination addresses, protocol(s), time of action, conditionals, e.g. if time  
20 20 of day is between 8:00 a.m. and 5:00 p.m. disable Internet access, and other variables related  
to the execution of the policy by the network devices.

25 The process steps, performed by the software product running on management station  
15 100, for the transformation of the rules to active packets will be described with reference to  
the flow diagram of Fig. 3 and process steps 310 through 380 illustrated therein. The AP  
engines depicted in Fig. 1 are devices capable of executing active packets, operating  
30 30 independently of the legacy systems supporting the network devices, and are configured as  
shown in Fig. 5. A discussion of the AP engine and its interrelationship with the base  
20 20 operating system will now ensue before continuing with the detailed description of the  
present invention.

35 In Fig. 5 the legacy systems 510 perform base services 520, which include, but are not  
limited to, recognizing input from the keyboard, sending output to the display screen, keeping  
track of files and directories on the memory devices, and controlling peripheral devices. The  
40 40 legacy systems can also perform policy enforcement, but require the system to be rebooted to  
purge the system of any currently executing policy. The AP engine is a self-contained  
operating environment that behaves as if it is a separate computer, i.e., similar in many  
respects to a virtual machine (VM). An example of a special type of AP engine is the JAVA  
45 45 Virtual Machine (JVM), which executes active packets. Since JAVA is an object-oriented  
30 30 language, the active packets executed by the JVM are JAVA objects. JAVA objects and  
JAVA applets are executed by the JVM on a level above the host operating system, i.e.,  
legacy system.

50

5           The AP engine design has two main advantages: 1) System independence, wherein an application, i.e., active packet, will run the same regardless of the hardware and software underlying the system, hence, an active packet formatted to execute on the AP engine can also be executable by a VM or a JVM; and 2) Security, since the AP engine has limited or no  
10           contact with the operating system, there is little possibility of an active packet damaging files or applications running on the legacy systems 510; this approach allows for the dynamic transfer and execution of active packets, i.e., objects or codes, without having to reboot the  
15           AP engine or legacy system, thereby interrupting the base services 520 being provided by the legacy systems 510.

10           As shown in Fig. 1 and the flow diagram of Fig. 3, the rules are inputted into management station 100 pursuant to step 310. After entering the rules, the rules are transformed into objects at step 320, each object having a format. The format comprises a data structure established according to an AP executable representation particular to the network device that will enforce the policy. Objects are higher level representations of the  
25           policy to be enforced by the enforcement devices 120, 130, 140, 160, 170, or 190 distributed throughout the network. In a preferred embodiment the created objects are active objects.

30           The rules are then transformed into objects by instantiation of classes in the management station 100 pursuant to the step 320. At step 330 the object is encoded. In a preferred embodiment the encoding is encapsulation. Encapsulation is a process whereby the  
20           objects representing one or more rules representing a policy is encoded making the object transportable. The encoding process removes the environment specific parameters from the object, thereby making it mobile. In a most preferred embodiment, the JAVA method of  
35           serializing the object is the encoding method employed. Programming languages which support the creation of objects, include, but are not limited to, JAVA, C++, CAML, Python,  
25           and Smalltalk.

40           At step 340 the software optionally signs the object file. The purpose of the signature is to provide the enforcement devices with information to allocate rights and privileges to the objects contained within the object file when the object or objects are executed on the  
45           enforcement device, i.e., one of the network devices 120, 130, 140, 160, 170, or 190 of Fig. 1.  
30           In a preferred embodiment the signature comprises a digital signature.

50           At step 350 the software stores the file on a memory device containing the objects along with their references to variables and methods necessary to execute the objects. A typical object file is depicted in Fig. 4, wherein the encoded object and references to the

5 encoded object are stored to a file or archived. The object file and its variables and any required methods for execution can be stored on a common memory device or on a directory server or distributed database. The object file and its variables can also be stored on management station 100, the network 110, or one of the policy enforcement devices as long  
10 5 references are provided so that the policy enforcement devices can access the appropriate memory device address to retrieve the necessary data for execution.

15 At step 360, the management station 100 signals the policy enforcement device that new policy, in the form of an object file, is available. Management station 100 either forwards the object file containing the required variables and methods or references to the  
20 10 variables and methods to execute the object and enforce the policy to the network 110 or to some other memory device, i.e. directory server, distributed database, etc., pursuant to step 370. It should be noted that since the network 110 generally operates on several levels each requiring different protocols that the variables and methods must be formatted, with the appropriate data structures and protocol, at management station 100 by the PDS software.  
25 15 The formatting is necessary to accommodate the myriad parameters necessary for a successful transmission and execution of the object and hence the enforcement of the specific portion of the policy assigned to that network device.

30 The technique of using objects to represent and enforce policy permits the dynamic modification of policy without having to reboot the enforcement device to purge it of a  
20 35 previous policy. Multiple policy rules are capable of being supported concurrently on each network device equipped with an AP engine. In the event that inconsistent policy rules are scheduled to be executed on the same enforcement device, several alternatives are available. A first or last in time approach can be taken wherein either the first policy rule or last policy rule provided to the enforcement device will take priority.

40 25 If the first in time approach is taken, the object representing the new policy rule may be loaded into memory, but the system resources will not be allocated to it until the first process is concluded. In the latter approach the first process may be terminated and its variables and states along with the attendant resources allocated to its execution are returned to their initial states before the execution of the new policy rule. Other approaches, as  
45 30 determined by the system administrator, can be implemented to overcome conflicts between objects and will be apparent to persons of ordinary skill in the art, and therefore will not be discussed at this time.

50

5 An example of the above process will now be given. The system administrator at  
management station 100 inputs a rule to discontinue traffic between hub 190 and the users  
attached to that node. The rule in question is selected from a table accessed by a GUI 101  
being executed on management station 100. The rule is then converted into an object,  
10 5 encoded with the proper format, i.e., data structures and protocol for the network device or  
devices that it is intended to be executed on, then saved into an object file, which is digitally  
15 signed. The object file along with any implementing code or data is sent to the network 110  
to be stored. In this example the object file and its attendant code, here code refers to the  
methods and data necessary to execute the object in the file, will most likely be sent to hub  
20 10 190, or router 160, or stored at the management station 100 in the memory 220. It should be  
noted that storing the object at management station 100 is not the preferred storage location.  
25 This is because if management station 100 is busy because of system congestion or loses its  
connection to the network 110 then the code and/or object necessary to effectuate the policy  
by the network devices 160 or 190 will not be accessible.  
30 15 Either hub 190 or router 160 can enforce the policy established by the system  
administrator. Router 160 could perform a primary or secondary function or it could  
complement hub 190 by enforcing a portion of the policy. Conversely, the object could be  
35 30 designated as private code signed such that only hub 190 or router 160 is permitted to access  
and execute the object file. The network devices have resources, i.e., logic, to receive and  
20 20 read the object provided by the management station 100 thereby determining access and  
execution rights and privileges. The following discussion will be premised on hub 190 being  
the only network device involved in this particular policy enforcement.

35 Fig. 6 depicts a flow diagram of the process steps performed and an execution  
environment set up by the software running on the AP engine at hub 190. At step 610, the  
40 40 AP engine is signaled that a new object or objects are ready for its use and execution.  
Pursuant to step 620 hub 190 accepts the object file or instruction to retrieve the object file  
45 and any code necessary to execute the object in the file. The object file signature is  
optionally verified, pursuant to step 630, and an execution environment 640 is established to  
execute the object.  
50 30 The establishment of the execution environment step 640 is to provide base services  
to the object for its use in its execution. This will include, but is not limited to, setting and  
clearing filters, setting and clearing timers, reading and writing states within the network  
device related to congestion, priority-based forwarding, and similar operations. The AP

5 engine is capable of executing multiple objects concurrently on hub 190. Pursuant to step  
650 hub 190 will then decode the object, i.e., examine the data within the object which  
specifies the variables and methods required for that object, and access its memory for the  
variables and methods necessary to execute the object. If the variables and methods required

10 5 by the object are not available in its memory, it will then retrieve and extract the variables  
and methods from the appropriate memory device, i.e., directory server or distributed  
database, using the references provided within the object by management station 100. As  
15 previously noted, the object may be designated as a private code and only accessed and  
executed by a particular network device.

10 10 After having retrieved the necessary methods and data to execute the object the object  
will be executed pursuant to step 660. In a preferred embodiment the decoding process is a  
20 method of unwrapping the encapsulated object. In a most preferred embodiment the  
decoding process is the JAVA method of de-serializing the object. The thread of execution  
associated with each object will then be executed invoking the method that the object  
25 15 implements, thereby providing hub 190 with the resources and functionality necessary to  
enforce the policy and block all traffic beyond its node.

30 20 The policy represented by the object at hub 190 may be of a limited duration or  
perpetual until either it is replaced or canceled by a subsequent object. Since the objects are  
capable of executing dynamically, without the need to power down the network device as in  
20 the conventional case, the implementation and modification of an object can be performed  
without regard to the functioning of the legacy system 510.

35 25 In general a currently running object that is scheduled to be terminated by a  
subsequent object will not terminate until the subsequent object is executed by its thread of  
execution. When a thread completes execution, the environment reclaims any resources it  
40 30 has allocated to it (in some systems this may be automatic, for example by system-wide  
garbage collection), and then determines what to do with the implementing code. It may  
decide to retain it in its code file library, or it may discard it.

45 35 If the network administrator wishes to stop the execution of the thread associated with  
an object, he uses the management station 100 to signal the network device to terminate the  
40 30 object's thread. Reasons for such termination include, but are not limited to, the network  
policy has changed or the administrator wishes to correct a mistake made in a previous policy  
specification. The enforcement device can also terminate the execution of an object's thread.  
50 This may be necessary, but is not limited to, an over consumption of resources, or when the

5 signer of the object is no longer trusted to execute code on the device, or the period over  
which the policy was being enforced has expired, or the triggering condition no longer exists  
on the system.

10 In an embodiment of the present invention the object is executed on a JAVA Virtual  
15 5 Machine (JVM) or similar device capable of running a mobile language such as, but not  
limited to, CAML, JAVA, Python, Smalltalk.

15 In an alternative embodiment, active networking can be performed using a script  
20 programming language (SPL) such as, but not limited to, Practical Extraction and Report  
Language (PERL), Tool Command Language (TCL), or shell type programming language.

20 10 The above-described embodiments of the present invention can be employed in any  
type of system wherein an AP engine, VM, or similar device has been established with the  
25 15 device and provides resources to enforce policy at the network device using the above-  
described active networking principles. Active networking includes, but is not limited to,  
sending active packets, i.e., objects or code, to a network device or a network intermediate  
30 20 device by the network management station in order to tailor network device behavior  
according to some system administration objective. Active networking also permits  
applications to send active packets to network devices, which lie between them and the  
destination of their traffic.

30 30 As demonstrated, active nodes can provide a larger variety of functionality with the  
20 35 same amount of dynamic memory wherein a passive network device must contain all of the  
code implementing its full feature set. Once a passive device is deployed, its feature set may  
only be modified by loading a new version of the software. Conversely, an active node need  
only have the code resident that is necessary to support the features currently in use and is  
capable of dynamic change without rebooting the device.

40 25 In addition to the active packet services described above, the AP engine provides the  
following general services. It provides a multiplexing substrate for executing threads. This  
allows the code from multiple active objects to execute concurrently without adversely  
45 30 affecting the executions associated with other active objects. It provides a security subsystem  
such as clocks, buffer memory, or network interfaces or they may be logical resources created  
by shared libraries or representing exported entry points of executing active code.

50 55 An active node is a device operating pursuant to a general-purpose operating system,  
such as one of the varieties of UNIX or it may be operating pursuant to an existing

5 networking device, which generally uses a proprietary or commercially supported real-time operating system (RTOS). The term software-based active node is used to describe the former and the term hybrid active node to describe the latter. In both cases only a part of the device is dedicated to active networking.

10 5 Traditionally, network devices do not support the notion of multi-user computations, even if they are based on multiprogramming operating systems, such as UNIX. While there may be administrative access control, which assigns different privileges to different users, generally these do not translate into processes running in separate address spaces. Rather, the 15 privileges are normally assigned to the terminal connection or console port, which the 10 administrator uses.

20 Active networking introduces new requirements that lead to more sophisticated access control mechanisms. For example, active code in execution may wish to communicate with other executing active code. The two threads may represent computations carried out on behalf of two different principals. This active networking provides for more dynamic system 25 15 administration and enforcement, heretofore not provided nor contemplated by conventional means.

30 The foregoing description of a preferred embodiment of the invention has been presented for purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise forms disclosed. Obviously, many modifications and 20 variations will be apparent to practitioners skilled in this art. It is intended that the following claims and their equivalents define the scope of the invention.

35

40

45

50

**Claims**

5

10

15

20

25

30

35

40

45

50

55

5

**WHAT IS CLAIMED IS:**

10

1. A system for dynamic policy management in a network, comprising:  
a management station coupled to said network, the management station including  
resources to store data defining policy rules for a device in the network;  
resources in the management station for producing an active packet including at least  
a variable and a method in response to the data defining the policy rule, the active packet  
having a format; and  
resources in the management station for sending the active packet to the network  
device adapted to read and execute the active packet according to the format.

20

2. The system according to claim 1, wherein the format comprises a data  
structure established according to a mobile programming language executable at the network  
device.

25

3. The system according to claim 2, wherein the data structure comprises an  
object.

30

4. The system according to claim 3, wherein the object comprises a JAVA  
object.

35

5. The system according to claim 4, wherein encoding is performed on the JAVA  
object.

40

6. The system according to claim 5, wherein the encoding comprises  
serialization.

45

7. The system according to claim 2, wherein the resources for sending include  
logic to transmit one of the variable and the method and a reference to the variable and the  
method to the network device.

50

8. The system according to claim 2, wherein the format of the mobile  
programming language supports co-location.

5           9.    The system according to claim 2, wherein the format of the mobile  
programming language supports enforcement by multiple network devices.

10           10.   The system according to claim 2, wherein the network device is an  
5           intermediate network device.

15           11.   The system according to claim 1, wherein the active packet comprises an  
object specified according to a mobile programming language, and the resources for sending  
include logic to encode the object.

10           12.   The system according to claim 11, wherein the mobile programming language  
20           comprises a scripting programming language.

15           13.   The system according to claim 12, wherein the scripting programming  
language comprises one of PERL, TCL, and a shell type programming language.

30           14.   The system according to claim 12, wherein the format of the scripting  
programming language supports co-location.

20           15.   The system according to claim 12, wherein the format of the scripting  
programming language supports enforcement by multiple network devices.

35           16.   The system according to claim 2, wherein the mobile programming language  
comprises an object.

40           17.   The system according to claim 16, wherein the object comprises a JAVA  
object.

45

50

55

5

18. The system according to claim 17, wherein encoding is performed on the JAVA object.

10

19. A system for dynamic policy management in a network, comprising: a network device coupled to said network, the network device including resources receive an active packet representing a policy rule from a second device in the network, the active packet having a format;

15

resources in the network device for decoding the active packet according to the

10 formal, the active packet including a variable and a method; and

resources in the network device for executing the active packet.

20

20. The system according to claim 19, wherein the format comprises a data structure established according to a mobile programming language.

25

21. The system according to claim 20, wherein the data structure comprises an object.

30

22. The system according to claim 21, wherein the object comprises a JAVA

20 object.

35

23. The system according to claim 20, wherein the mobile programming language comprises JAVA.

40

24. The system according to claim 19, wherein the resources for receiving include logic to receive one of the variable and the method and a reference to the variable and the method from the second network device.

45

25. The system according to claim 19, wherein the format of the active packet 30 supports co-location.

50

26. The system according to claim 19, wherein the format of the active packet representing policy supports enforcement by multiple network devices.

5

27. The system according to claim 19, wherein the network device comprises a network intermediate device.

10

5 28. The system according to claim 27, wherein the network intermediate device comprises a router.

15

29. The system according to claim 27, wherein the network intermediate device comprises a hub.

10

20

30. The system according to claim 27, wherein the network intermediate device comprises a switch.

25

31. The system according to claim 27, wherein the network intermediate device comprises an adapter.

30

32. The system according to claim 27, wherein the network intermediate device comprises a NIC including the resources for executing the active packet.

35

20 33. The system according to claim 27, wherein the network intermediate device comprises a bridge.

40

34. The system according to claim 27, wherein the network intermediate device comprises a repeater.

45

25 35. The system according to claim 20, wherein the mobile programming language comprises a scripting programming language.

50

55

5

36. The system according to claim 35, wherein the scripting programming language comprises one of PERL, TCL, and a shell type programming language.

10

5 37. The system according to claim 35, wherein the scripting programming language supports co-location.

15

38. The system according to claim 35, wherein the format of the active packet representing policy supports enforcement by multiple network devices.

10

20 39. A system for dynamic policy management in a network, comprising:

a management station and a network device coupled to said network, wherein the management station includes:

resources to store data defining a policy rule for a device coupled to the network;

25

15 resources in the management station for producing an active packet including a variable and a method in response to the data defining the policy rule, the active packet having a format; and

30

resources in the management station for sending the active packet to the network device, wherein the network device includes resources to receive, decode, and execute the active packet according to the format.

35

40 40. The system according to claim 39, wherein the format comprises a data structure established according to a mobile programming language executable at the network device.

45

25 41. The system according to claim 40, wherein the data structure comprises an object.

45

30 42. The system according to claim 41, wherein the object comprises a JAVA object and the resources for sending include logic to encode the object.

50

43. The system according to claim 42, wherein the resources for sending include logic to transmit the variable and one of the method and a reference to the method to the

5 network device.

44. The system according to claim 43, wherein the method of encoding the object comprises serialization.

10 5

45. The system according to claim 44, wherein the mobile programming language comprises JAVA.

15

46. The system according to claim 45, wherein the resources for receiving include 10 logic to receive the variable and one of the method and reference to the method from the management station.

20

47. The system according to claim 40, wherein the mobile programming language comprises a scripting programming language.

25 15

48. The system according to claim 47, wherein the scripting programming language is one of PERL, TCL, and a shell-type programming language.

30

49. The system according to claim 47, wherein the scripting programming 20 language supports co-location.

35

50. The system according to claim 47, wherein the scripting programming language supports enforcement by multiple network devices.

40 25

51. The system according to claim 47, wherein the network device comprises an intermediate network device.

45

50

5

52. A system providing dynamic policy management by a method, the system comprising:

10

5 an interface adapted to receive instructions characterizing policy regarding control of a network; and

15

an active node connected to the interface which provides a packet to the network, the packet including one of a variable and a method and a reference to the variable and the method, executable on the network to set up a process to enforce at least a portion of the policy.

10

20

53. The system providing dynamic policy management according to claim 52, wherein the instructions characterizing policy comprise one or more rules defining policy.

25

54. The system providing dynamic policy management according to claim 53, wherein the active node includes logic to translate the one or more rules into the packet.

30

55. The system providing dynamic policy management according to claim 52, wherein the packet comprises a data structure created according to a policy definition language.

20

35

56. The system providing dynamic policy management according to claim 55, wherein the policy definition language comprises a mobile programming language.

40

57. The system providing dynamic policy management according to claim 56, wherein the mobile programming language comprises an object oriented programming language.

50

55

5

59. The system providing dynamic policy management according to claim 56, wherein mobile programming language comprises a scripting programming language.

10

5 60. The system providing dynamic policy management according to claim 59, wherein scripting programming language comprises one of PERL, TCL, and a shell-type programming language.

15

10 61. The system providing dynamic policy management according to claim 52, wherein the active node comprises resources to signal a node on the network that a new policy is available, and wherein the node retrieves a packet file containing one of the packet 20 and a reference to the packet, and operates pursuant to a second process.

25

62. The system providing dynamic policy management according to claim 61, 15 wherein a management station includes logic to combine plurality of packets within the packet file wherein the data in the packet file indicates privileges that the packet is granted.

30

63. The system providing dynamic policy management according to claim 62, wherein the packet file data comprises a digital signature.

20 64. The system providing dynamic policy management according to claim 63, including resources to store the packet on the active node.

35

65. The system providing dynamic policy management according to claim 64, wherein the packet is stored on a memory device on the network.

25

40 66. The system providing dynamic policy management according to claim 52, wherein the packet supports co-location.

45

67. The system providing dynamic policy management according to claim 52, 30 wherein the packet supports enforcement by multiple network devices.

50

68. The system providing dynamic policy management according to claim 52, wherein the network device comprises an intermediate network device.

5

69. The system providing dynamic policy management according to claim 67, wherein the network device comprises a node.

10

70. The system providing dynamic policy management according to claim 52, wherein the network node comprises a second active node.

15

71. A system providing dynamic policy management by a method, the system comprising:

20

an network node adapted to receive a packet, created by a first process, representing policy for control of a network; and resources in the network node capable of executing a packet including one of a variable and a method and instructions to locate the variable and the method, executable on the network node to enforce a portion of the policy.

25

72. The system providing dynamic policy management according to claim 71, wherein the packet comprises a data structure created according to a policy definition language.

30

73. The system providing dynamic policy management according to claim 72, wherein the policy definition language comprises a mobile programming language.

35

74. The system providing dynamic policy management according to claim 73, wherein the mobile programming language comprises JAVA.

40

75. The system providing dynamic policy management according to claim 73, wherein mobile programming language comprises a scripting programming language.

45

76. The system according to claim 75, wherein the scripting programming language is one of PERL, TCL, and a shell-type programming language.

30

77. The system providing dynamic policy managing according to claim 71, wherein the network node includes resources to signal a node on the network that a new policy is available, and wherein the node retrieves a packet file containing one of the packet

5 and a reference to the packet and operates pursuant to a second process.

78. The system providing dynamic policy management according to claim 71, wherein the packet supports co-location.

10 5

79. The system providing dynamic policy management according to claim 71, wherein the active packet supports enforcement by multiple network devices.

15

80. A system for dynamic policy management in a network, comprising:

10 an active node and a network node coupled to said network, wherein the active node includes:

20 resources to store data defining a policy rule for a device coupled to the network; resources in the active node for producing a packet including a variable and a method in response to the data defining the policy rule; and

25 15 resources in the active node for sending a packet file containing one of the packet and a reference to the packet to the network node, wherein the network node includes resources to receive, decode, and execute the packet.

30

81. The system according to claim 80, wherein the packet comprises an object specified according to an policy definition language, and the resources for sending include logic to encode the packet.

35

82. The system according to claim 81, wherein the resources for sending include logic to transmit one of the variable and the method and the reference to the variable and the method to the network node.

40

45

50

5

83. The system according to claim 81, wherein the policy definition language comprises a mobile programming language.

10

5 84. The system according to claim 83, wherein the mobile programming language comprises JAVA and the packet comprises a JAVA object.

15

85. The system according to claim 84, wherein a method of encoding the JAVA object comprises serialization.

10

20 86. The system according to claim 83, wherein the mobile programming language comprises a scripting programming language.

25

87. The system according to claim 86, wherein the scripting programming language is one of PERL, TCL, and a shell-type programming language.

30

88. The system according to claim 80, wherein the resources for receiving include logic to receive one of the packet and a reference to the packet from the active node.

35

20 89. The system according to claim 81, wherein the policy definition language supports co-location.

40

90. The system according to claim 81, wherein the policy definition language supports enforcement by multiple network nodes.

45

50

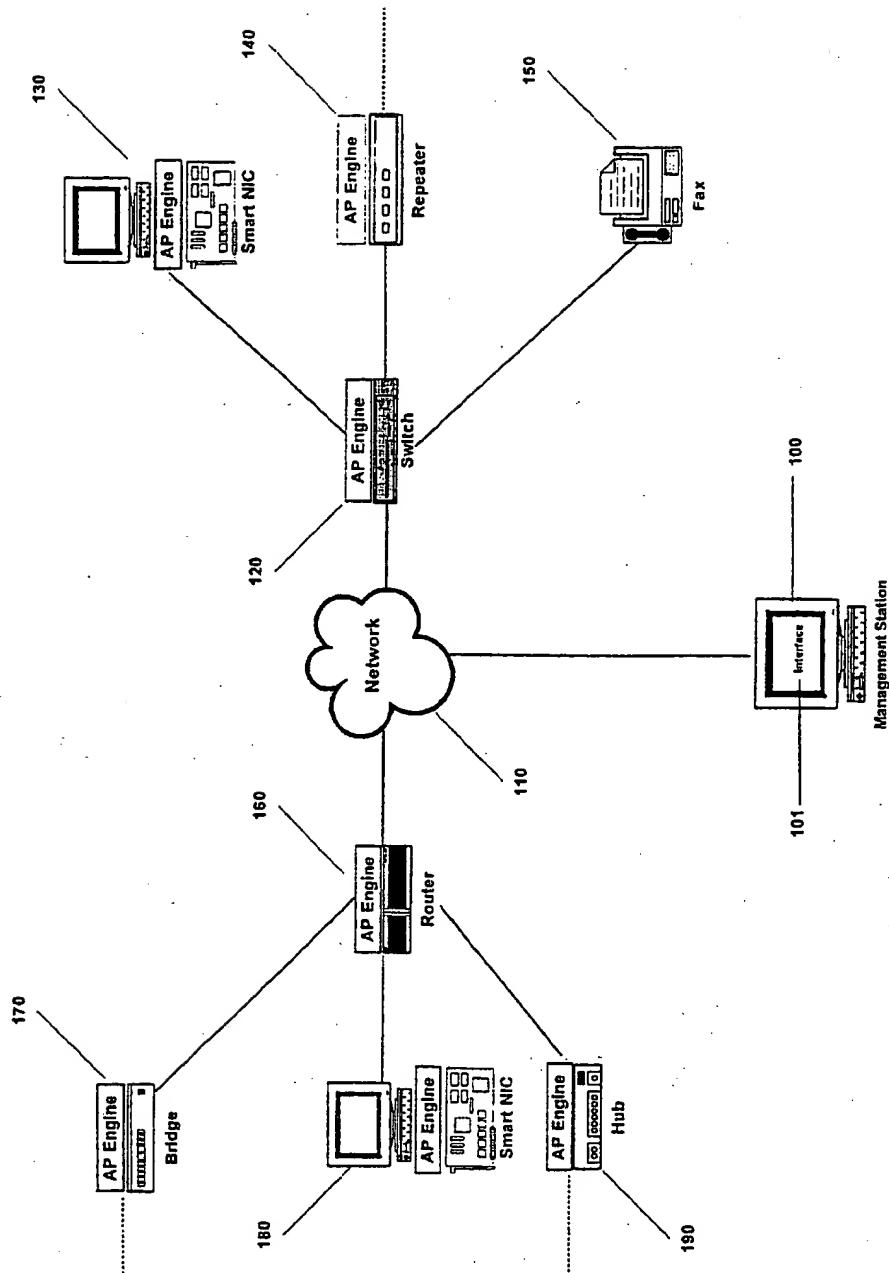


FIG. 1

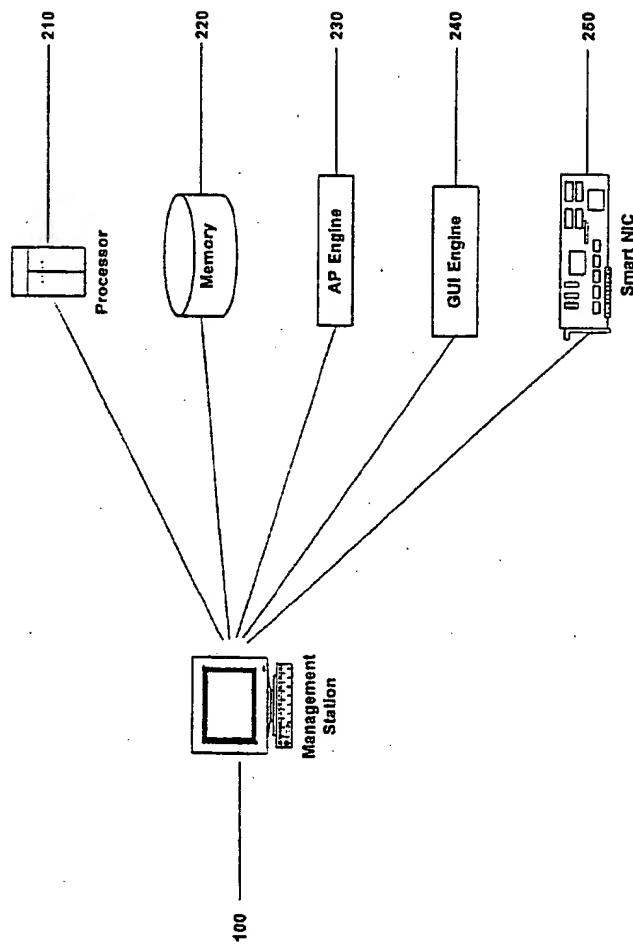


FIG. 2

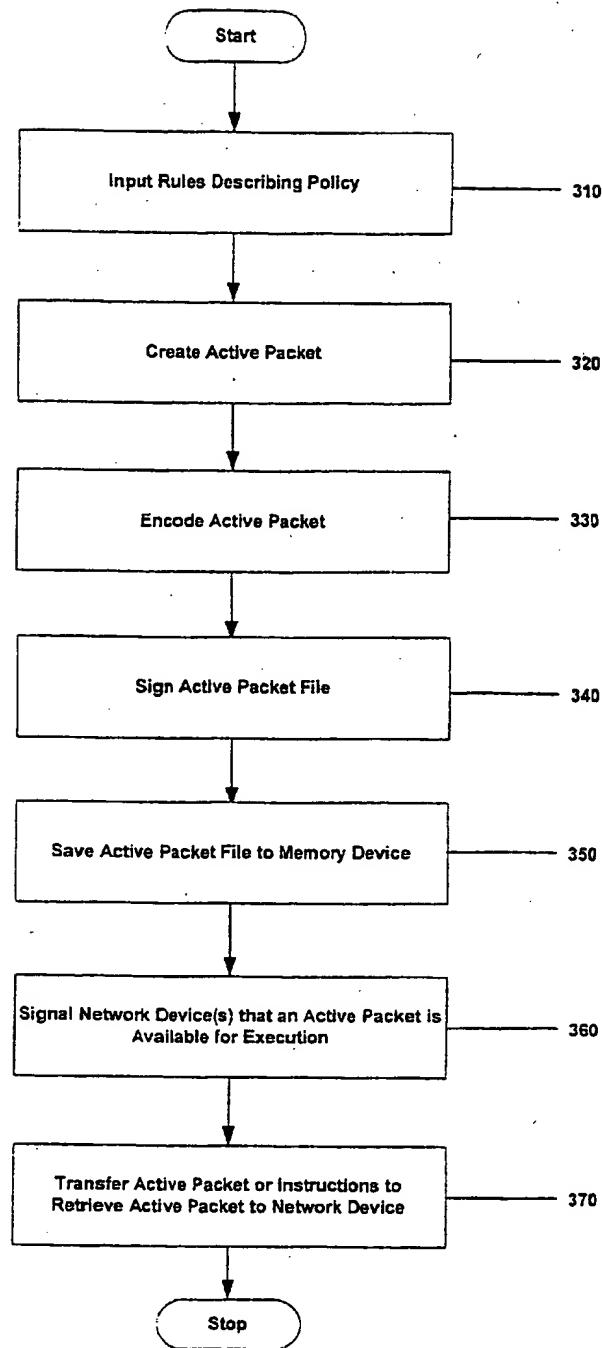


FIG. 3

Encoded Active Packet # 1
Encoded Active Packet # 2
:
:
Encoded Active Packet # N
Reference to Executable/ Data for Active Packet # 1
Reference to Executable/ Data for Active Packet # 2
:
:
Reference to Executable/ Data for Active Packet # N

FIG. 4

ARCHIVE / FILE

ACTIVE PACKETS	540
AP ENGINE	530
BASE SERVICES	520
LEGACY SYSTEMS	510

SYSTEM HIERARCHY

FIG. 5

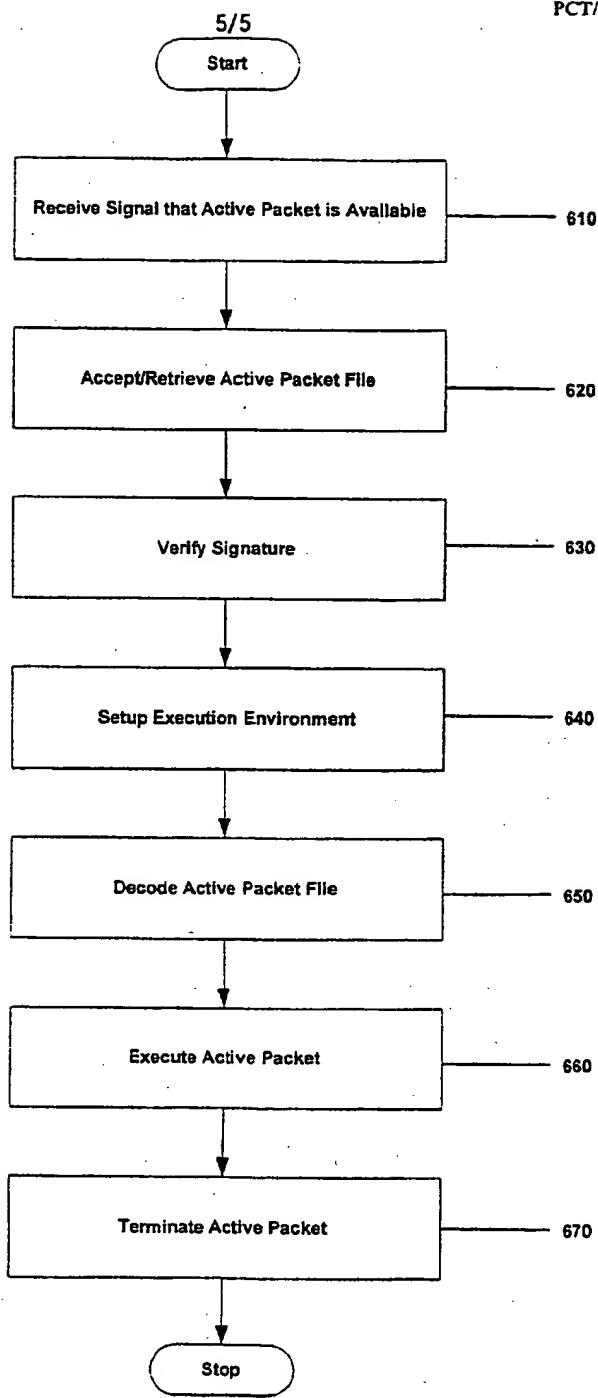


FIG. 6

## INTERNATIONAL SEARCH REPORT

International application No.  
PCT/US99/28199

<b>A. CLASSIFICATION OF SUBJECT MATTER</b>																				
IPC(6) :G06F 15/173 US CL :709/223, 245 According to International Patent Classification (IPC) or to both national classification and IPC																				
<b>B. FIELDS SEARCHED</b>																				
Minimum documentation searched (classification system followed by classification symbols) U.S. : 709/201, 223, 224, 226, 244, 245, 300, 303; 370/231, 242, 464, 465																				
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched IEEE periodicals & conferences																				
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) EAST text search terms: network policy, network management/monitoring, Java, OOP, MIB, ORB																				
<b>C. DOCUMENTS CONSIDERED TO BE RELEVANT</b>																				
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.																		
Y	US 5,426,421 A (GRAY) 20 JUNE 1995 ABSTRACT, Column 2, Lines 4-41, Column 3, Line 48 through Column 5, Line 13, Column 8, Line 65 through Column 13, Line 61	1-90																		
Y,P	US 5,889,953 A (THEBAUT et al.) 30 MARCH 1999 ABSTRACT, Column 2, Lines 4-42, Column 3, Line 16 through Column 6, Line 23, Column 11, Lines 33-48, Column 13, Line 22 through Column 14, Line 4	1-90																		
Y	AGHA, G.A.; "Modular heterogeneous system development: a critical analysis of Java"; Proceedings of the Seventh Heterogeneous Computing Workshop, 30 MARCH 1998; IEEE Catalog number 98EX126; ISBN: 0-8186-8365-1; pages 144-155	1-90																		
<input checked="" type="checkbox"/> Further documents are listed in the continuation of Box C. <input type="checkbox"/> See patent family annex.																				
<table border="0"> <tr> <td>* Special categories of cited documents:</td> <td>*T*</td> <td>later documents published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</td> </tr> <tr> <td>"A" document defining the general state of the art which is not considered to be of particular relevance</td> <td>"X"</td> <td>document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone</td> </tr> <tr> <td>"E" earlier document published on or after the international filing date</td> <td>"Y"</td> <td>document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art</td> </tr> <tr> <td>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</td> <td>"&amp;"</td> <td>document member of the same patent family</td> </tr> <tr> <td>"O" document referring to an oral disclosure, use, exhibition or other means</td> <td></td> <td></td> </tr> <tr> <td>"P" document published prior to the international filing date but later than the priority date claimed</td> <td></td> <td></td> </tr> </table>			* Special categories of cited documents:	*T*	later documents published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention	"A" document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone	"E" earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art	"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family	"O" document referring to an oral disclosure, use, exhibition or other means			"P" document published prior to the international filing date but later than the priority date claimed		
* Special categories of cited documents:	*T*	later documents published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention																		
"A" document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone																		
"E" earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art																		
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family																		
"O" document referring to an oral disclosure, use, exhibition or other means																				
"P" document published prior to the international filing date but later than the priority date claimed																				
Date of the actual completion of the international search  25 FEBRUARY 2000	Date of mailing of the international search report  21 MAR 2000																			
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer MARC THOMPSON Telephone No. (703) 305-3900																			

## INTERNATIONAL SEARCH REPORT

International application No.  
PCT/US99/28199

## C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A,P	US 6,000,045 A (LEWIS) 07 DECEMBER 1999 Entire document	1-90
A,P	US 5,905,900 A (COMBS et al.) 18 MAY 1999 Entire document	1-90
A,P	US 5,893,083 A (ESHGHI et al.) 06 APRIL 1999 Entire document	1-90
A,P	US 5,872,928 A (LEWIS et al.) 16 FEBRUARY 1999 Entire document	1-90
A,P	US 5,870,561 A (JARVIS et al.) 09 FEBRUARY 1999 Entire document	1-90
A	US 5,608,720 A (BIEGEL et al.) 04 MARCH 1997 Entire document	1-90
A	MAZUMDAR, S. et al.; "Design of Protocol Independent Management Agent to Support SNMP and CMIP Queries"; Integrated Network Management, III; Elsevier Science Publishers B.V. (North-Holland), pages 377-388	1-90

This Page Blank (uspto)